Thieme

Anatomy of the great and small saphenous veins

Anatomie der V. saphena magna und parva

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ABSTRACT

Varicose veins are by far the most frequent illness phlebologists deal with. Great and small saphenous vein are nearly always involved in the pathological recirculation. Their anatomy is constant, excepting for variation in their course and junctions. In times where we can apply patient tailored treatments, adapting different techniques and strategies to the findings, we can offer the least harming method after analyzing the anatomy of the patient and perhaps reduce recurrence rate. Today ultrasound is the gold standard to explore varicose veins. Thus, information about anatomy of superficial leg veins has to be implemented with the ultrasound anatomy of the situs. The present article describes the anatomy of the saphenous veins with schematic images and ultrasound examples of the typical findings.

ZUSAMMENFASSUNG

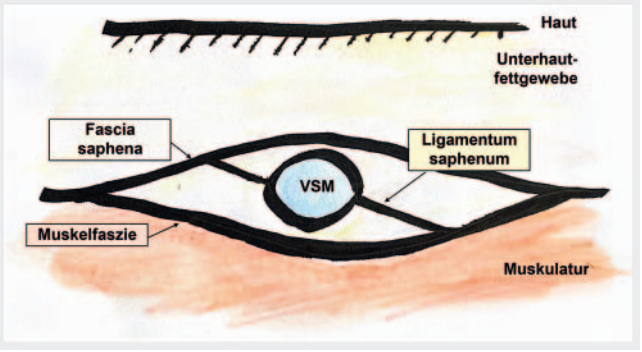
In der Phlebologie ist die Varikose die häufigste Erkrankung. Dabei sind die V. saphena magna und V. saphena parva meist in die pathologische Rezirkulation involviert. Ihre Anatomie ist relativ konstant, bis auf Feinheiten im Mündungsbereich und Verlauf, die jedoch in einer Zeit, in der es verschiedene Techniken und Strategien zur Behandlung der Varikose gibt, mit ins Kalkül gezogen werden müssen. Somit kann man es erlauben, den Patienten den möglichst nebenwirkungsarmen Eingriff mit der geringsten Rezidivhäufigkeit anzubieten. Der Ultraschall ist heute der Goldstandard in der Untersuchung der Beinvenen; daher muss die Anatomie der Venen immer auch im Ultraschall verstanden werden. Der Artikel beleuchtet schematisch die Anatomie und ergänzt die Beschreibung mit typischen Schallbildern zur V. saphena magna und parva.

Introduction

The term ‘saphenous’ was first coined by Avicenna, from the Arabic *el safin*, which means ‘concealed’ [1]. In each leg, the great saphenous vein (*V. saphena magna*) runs along the inner aspect of the leg, while the small saphenous vein (*V. saphena parva*) runs along the back of the calf. These two veins are the ones most frequently involved in pathological conditions of the superficial venous system requiring treatment. In the proximal thigh, there may be two accessory saphenous trunks – the anterior accessory saphenous vein (*V. saphena accessoria anterior;* see the article by Riabinska and Mendoza in this issue) and the posterior accessory saphenous vein (*V. saphena accessoria posterior;* see Valesky and Brenner in this issue).

From the various names used in the literature for the saphenous veins, the International Consensus on the Nomenclature of the Anatomy of the Leg Veins (UIP 2001, Rome, published in 2002 [2]), determined that ‘great saphenous vein (GSV)’ and ‘small saphenous vein (SSV)’ were used most often. The organisation of the veins into different anatomical compartments was also defined. The veins had formerly been divided into the ‘deep veins’ (running within the muscle fascia) and the ‘superficial veins’ (running outside the muscle fascia). The deep venous system remained the same in the new nomenclature, designated network 1 (N1). In accordance with the papers by Caggiati and Ricci [3–5], the superficial veins were divided into two anatomical compartments: the saphenous compartment (network 2; N2) containing

▶ **Fig. 1** Course of the great saphenous vein in the leg (see text for explanation). Source: Arrien GmbH.



▶ **Fig. 2** Diagram showing the great saphenous vein in the fascial compartment, as it usually appears in ultrasound scans of the thigh (cross-section through the GSV). Haut = Skin, Unterhautfettgewebe = subcutaneous tissue, Muskelfaszie = Muscle fascia, Muskulatur = Muscle. Source: Arrien GmbH.

▶ **Table 1** Distribution of segmental aplasia of the great saphenous vein after Seidel [10], cf. ▶ **Fig. 3a–f**. Out of 2665 legs, 442 (16.7 %) showed aplasia. The third column (% of aplasias) gives the percentage of each type of aplasia in relation to all the cases of aplasia found, while the figure in the fourth column (% overall) is the percentage of aplasias found in all the legs examined.

Aplasia type	Number	% of aplasias	% overall
I	18	4.1 %	0.7 %
II	61	13.8 %	2.3 %
III	319	72.2 %	12 %
IV	15	3.4 %	0.6 %
V	28	6.3 %	1.1 %
VI	1	0.2 %	0.04 %
Total	442	100 %	16.74 %

the saphenous veins and the epifascial compartment with all the other superficial leg veins (network 3; N3).

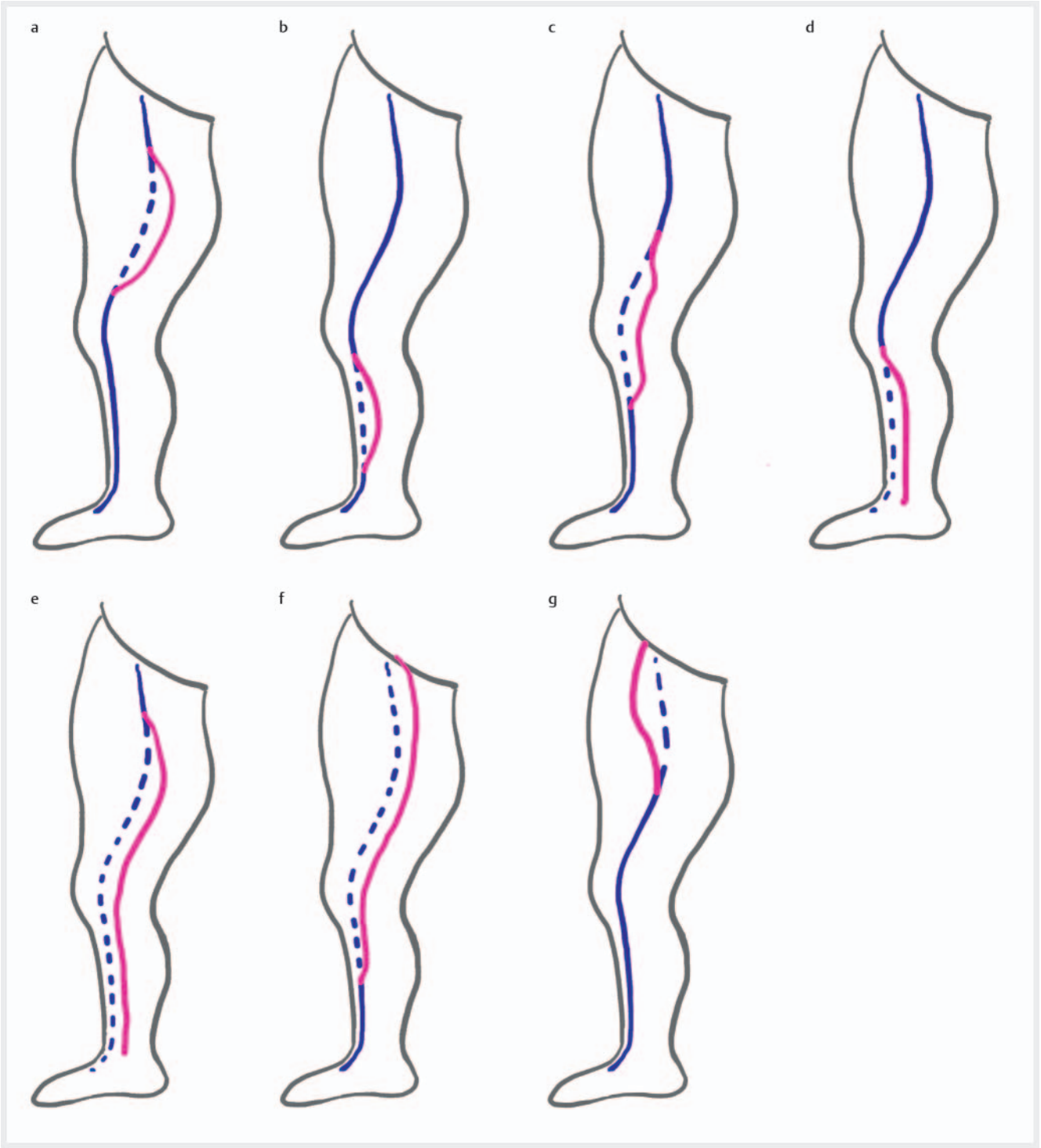
The saphenous veins therefore run directly on the muscle fascia, separated from the subcutaneous fatty tissue by their own fascia, the saphenous fascia. A ligament (the saphenous ligament) fixes the saphenous vein to the muscle fascia and the saphenous fascia, which is why the saphenous veins almost never follow a winding course (▶ **Fig. 1, 2**).

Course of the great saphenous vein

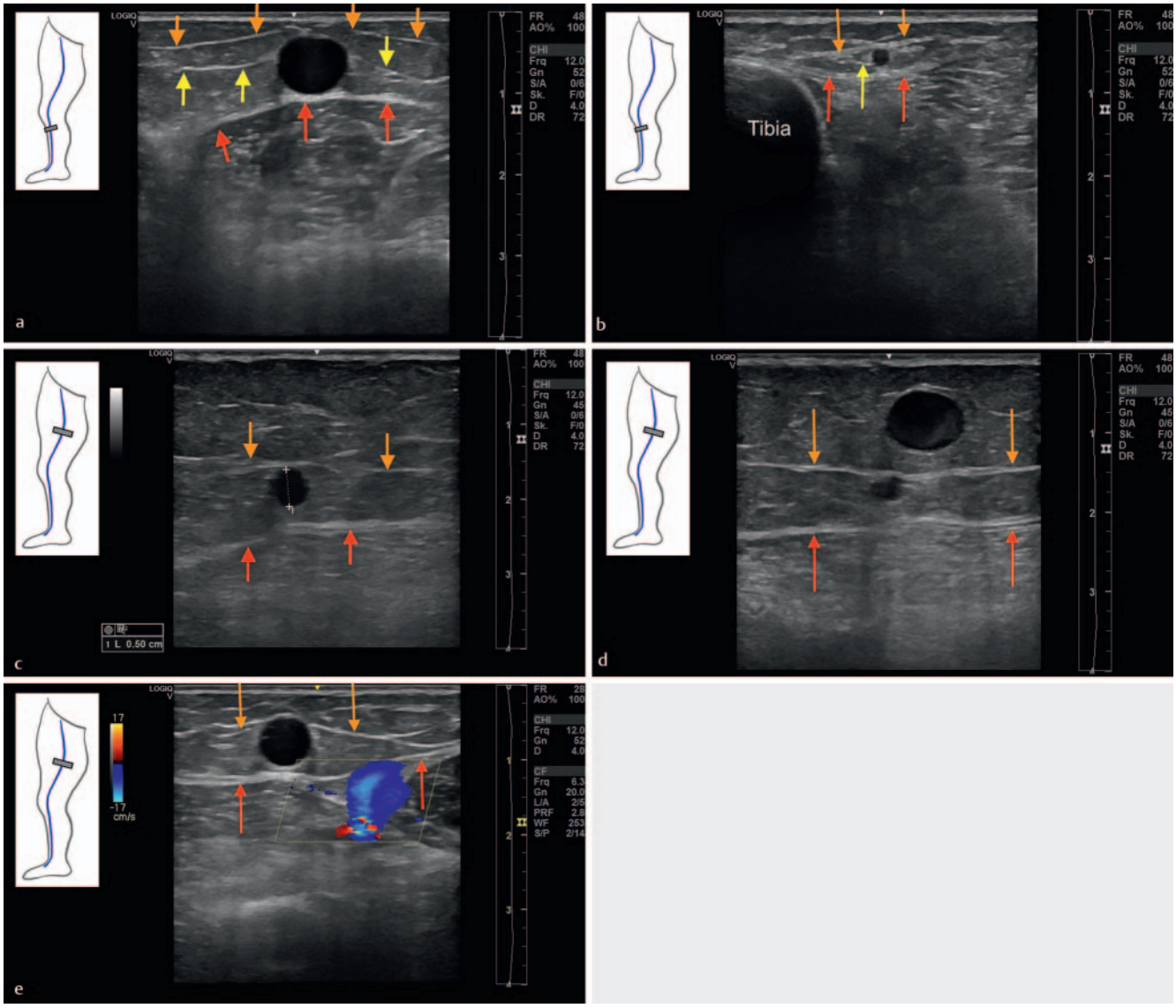
The great saphenous vein arises from the veins on the dorsum of the foot and can be seen on the inner aspect of the ankle anterior to the medial malleolus. It then runs proximally parallel to the tibial crest, turning slightly posterior just below the knee and continuing on the medial aspect of the thigh to the groin (▶ **Fig. 1**). The great saphenous vein opens fairly consistently into the common femoral vein below the inguinal ligament. It receives various tributaries, forming the structure known in German as the 'venous star'. Due to its aspect like a bishop's hook, this region has been referred to as 'the crosse' but is now termed as the saphenofemoral junction (SFJ), which will be described in the next paragraph.

The great saphenous vein always runs in its fascial compartment. A doubled great saphenous vein is therefore only possible when there are indeed two parallel lumens in the compartment. This variant of normal occurs in only 1 % of cases [6]. They are then bound together with part of the saphenous ligament. The earlier high figure of a 27 % duplication of the great saphenous vein [7] is the sum of the true doubled vessels (1 %) and an extrafascial superficial accessory saphenous vein running parallel to the GSV in 26 % of cases [6].

Segmental aplasia of the great saphenous vein is present if no lumen can be demonstrated in the fascial compartment on ultrasound scanning or in the dissected specimen. On histology, there is always a cellular rudiment of the GSV without a lumen [8]. This variant is found in the thigh in 12 % of people with healthy veins and 25 % of patients with reflux [9]. Some authors also distinguish hypoplasia: in this case the great saphenous vein can still be demonstrated but the lumen is very small in diameter, measuring between 1 and 2 mm. An accessory superficial saphenous vein drains into the great saphenous vein distal and proximal to these aplastic or hypoplastic segments, allowing a continued flow by providing a bypass to the aplastic segment – the flow will be antegrade in a healthy vein or retrograde if there is valvular incompetence. This is not an extrafascial saphenous vein, but rather a superficial bypass.



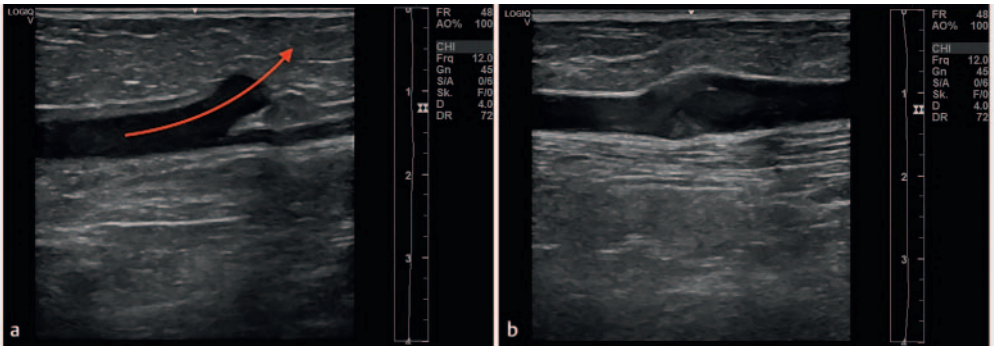
▶ **Fig. 3 a–f** Variants of GSV aplasia after Seidel. **a** Type I: Segmental GSV aplasia in the thigh. Source: Arrien GmbH. **b** Type II: Segmental GSV aplasia in the calf. Source: Arrien GmbH. **c** Type III: Segmental GSV aplasia over the knee Source: Arrien GmbH. **d** Type IV: Segmental GSV aplasia in the calf; the GSV can no longer be demonstrated distally in the compartment. Source: Arrien GmbH. **e** Type V: Segmental GSV aplasia in the thigh, knee, and calf; the GSV can no longer be demonstrated distally in the compartment. Source: Arrien GmbH. **f** Type VI: Segmental GSV aplasia from the junction through the thigh and knee; the GSV can be demonstrated only in the fascial compartment in the calf. Source: Arrien GmbH. **g** Further variants proposed by Mendoza after Riabinska: aplasia in the thigh to the junction of the great saphenous vein, the anterior accessory saphenous vein serves as a bypass for the blood. Source: Arrien GmbH.



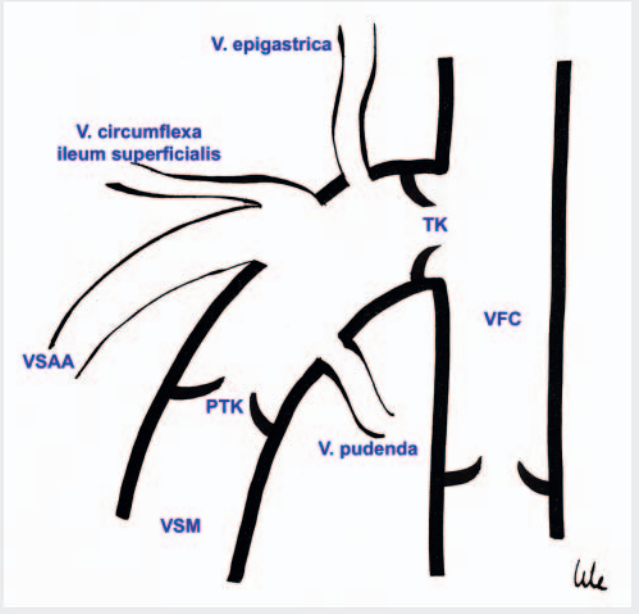
▶ **Fig. 4** Transverse section through the great saphenous vein (position of the probe, see icon). Saphenous fascia (orange arrows), saphenous ligament (yellow arrows), muscle fascia (red arrows). **a** Transverse section through the inner aspect of the calf: large-diameter (refluxing) great saphenous vein in an extremely thin patient. Hardly any fatty tissue between the saphenous fascia and the skin. The saphenous fascia can be seen, as well as the saphenous ligament and the muscle fascia. Source: Arrien GmbH. **b** Transverse section through the inner aspect of the calf showing a competent (narrower) great saphenous vein and fascia in association with the tibial crest. Source: Arrien GmbH. **c** Transverse section through the inner aspect of the thigh with slightly widened great saphenous vein (5 mm) with very mild reflux; the saphenous fascia and muscle fascia can be seen but not the saphenous ligament. Source: Arrien GmbH. **d** Distinguishing between the saphenous trunk and a tributary vein: the tributary (refluxing, widened) lies between the saphenous fascia and the skin; the great saphenous vein (competent, narrow) runs in the fascial compartment. Source: Arrien GmbH. **e** Distinguishing between the saphenous trunk and a perforator connecting the superficial venous system with the deep veins: the perforating vein (shown here in blue) passes through the muscle fascia into the deep tissues. Source: Arrien GmbH.

Seidel analysed the possible types of aplastic segment and described six types (▶ **Fig. 3a–g**, ▶ **Table 1**) [10]. The author considers that there is yet another type, with aplasia of the GSV from distal to the terminal valve to the middle of the thigh, with a bypass via the anterior accessory saphenous vein; this variant is described in the article by Riabinska in this issue (▶ **Fig. 3g**).

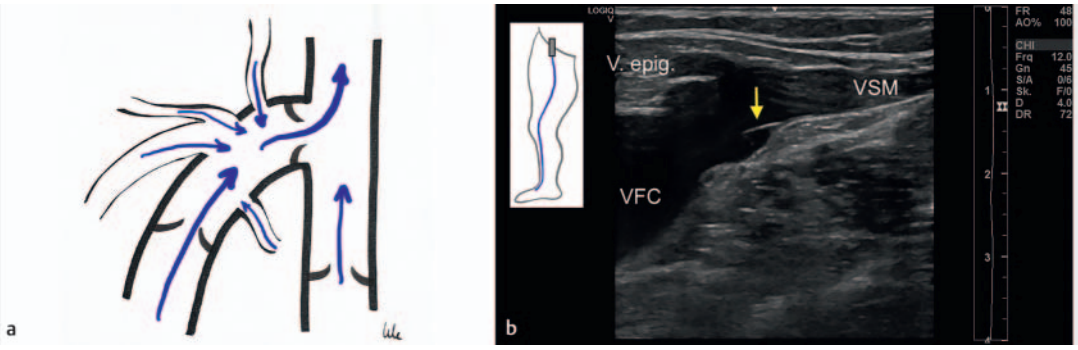
On ultrasound scanning, the great saphenous vein has a relatively consistent diameter through the calf and thigh (with the exception of the groin). It is quite small in those with healthy veins, being less than 4 mm in the thigh [11]. In cross-section, the vein is round and embedded in the fascial compartment, sometimes also with a visible saphenous ligament (▶ **Fig. 4a–c**). As tributaries of the main venous trunk drain from the saphenous compartment by running through the saphenous fascia to the skin, tributaries always run between the saphenous fascia and the skin (▶ **Fig. 4d, 5b**). Perforating veins on the other hand penetrate the muscle fascia and run away from the skin surface (▶ **Fig. 4e**).



▶ **Fig. 5** Longitudinal appearance of the great saphenous vein. **a** Parallel course of the vein walls; the opening of the tributary can be seen in the centre of the picture. The left part is refluxing, the right part is competent, the reflux drains into the tributary (red arrow). The diameter of the distal GSV (seen on the right of the picture) is therefore smaller than that of the proximal GSV (seen on the left). Source: Arrien GmbH. **b** Valve along the GSV with widening of the vein. Source: Arrien GmbH.



▶ **Fig. 6** Diagram of the saphenofemoral junction. VFC = common femoral vein (VFC: V. femoralis communis), TK = terminal valve, PTK = preterminal valve, VSM = great saphenous vein (VSM: V. saphena magna), VSAA = anterior accessory saphenous vein (VSAA: V. saphena accessoria anterior). Source: Arrien GmbH.



▶ **Fig. 7** **a** Normal flow pattern at the saphenofemoral junction, the terminal and preterminal valves are competent. Source: Arrien GmbH. **b** Demonstration of the terminal valve (yellow arrow) on ultrasound scan, V. epig = epigastric vein. VSM = Great saphenous vein, VFC = Common femoral vein. Longitudinal section through the groin. Source: Arrien GmbH.

In longitudinal section, the saphenous vein appears as a smooth tube with parallel walls (▶ **Fig. 5a**). If a segment of the vein shows reflux and the reflux is transmitted back to the tributary, we see a sudden increase in size. The valves are often visible along the course of the vein and the vein walls widen at these points (▶ **Fig. 5b**).

Draining of the great saphenous vein

The great saphenous vein drains into the common femoral vein at the level of the inguinal ligament. It typically has two valves in this region: the terminal valve and the preterminal valve (see ▶ **Fig. 6, 7**), although they are not present in every individual and often cannot be seen on ultrasound [12].

The great saphenous vein is often bent at the junction, giving rise to the earlier name of 'crosse' (from the French) for its resemblance to a bishop's hook. The opening in the common femoral vein through which the blood flows from the great saphenous vein to the deep leg vein is called the 'ostium' and the whole region is known as the saphenofemoral junction. Here, the great saphenous vein receives various tributaries from all sides, giving rise to the name of "venous star" in German. These tributary veins may or may not all be present; they may open individually or collectively into the great saphenous vein, or even directly into the deep veins of the leg.

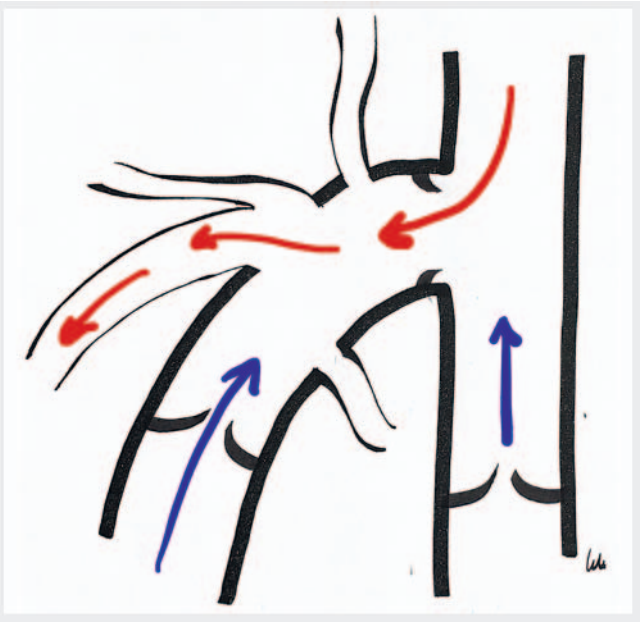
Tributaries that drain from above are the superficial circumflex iliac vein and the epigastric vein from above and lateral, and the pudendal veins from above and medial. The anterior accessory saphenous vein drains from below and lateral. It may open alone but often drains together with the epigastric vein into the great saphenous vein. Coming from below and medially, the posterior accessory saphenous vein rarely drains at the saphenofemoral junction but usually more distally (▶ **Fig. 6**).

Depending on whether the valves in the SFJ are competent or not, there are various constellations of reflux. If all valves close, there is only an antegrade flow draining to the deep leg vein. Flow in the superior SFJ tributaries is directed towards the foot but usually does not last longer than 0.5 seconds after a Valsalva or other reflux provocation manoeuvre [13].

If the preterminal valve is competent but the terminal valve is not, there is a type 1 Stücker reflux [14] into the anterior accessory saphenous vein (see article by Riabinska in this issue). The great saphenous vein shows reflux only at the junction itself, as more distally the competent preterminal valve protects the vein from reflux (▶ **Fig. 8**).

If the terminal valve is competent but the preterminal valve is not, we do not find any reflux into the trunk vein from the deep veins but there is reflux from the tributaries around the SFJ (type 2 Stücker reflux) [14], in various combinations: from only one superior vein (▶ **Fig. 9a, b**), only the pudendal vein (▶ **Fig. 9c**) or both (▶ **Fig. 9d**). Such reflux is not rare, with a frequency of 21.3 % [15] (cf. table in the article by Riabinska in this issue).

In principle it is possible that the superior reflux fills not only the anterior accessory saphenous vein but also the great saphenous vein (▶ **Fig. 10**); according to Zollmann, this occurs in 2 % of cases [15].



▶ **Fig. 8** Stücker type 1. Incompetent terminal valve and competent preterminal valve with reflux from the deep leg vein across the saphenofemoral junction into the anterior accessory saphenous vein. Source: Arrien GmbH.

When both the terminal and preterminal valves are incompetent, there is an axial or type 3 Stücker reflux (▶ **Fig. 11a**). The reflux across the terminal valve is measured directly at its opening (▶ **Fig. 11b**).

In 7.6 % of cases [15], we find an axial reflux from the deep vein with simultaneous drainage via the great saphenous vein and the anterior accessory saphenous vein (▶ **Fig. 12**).

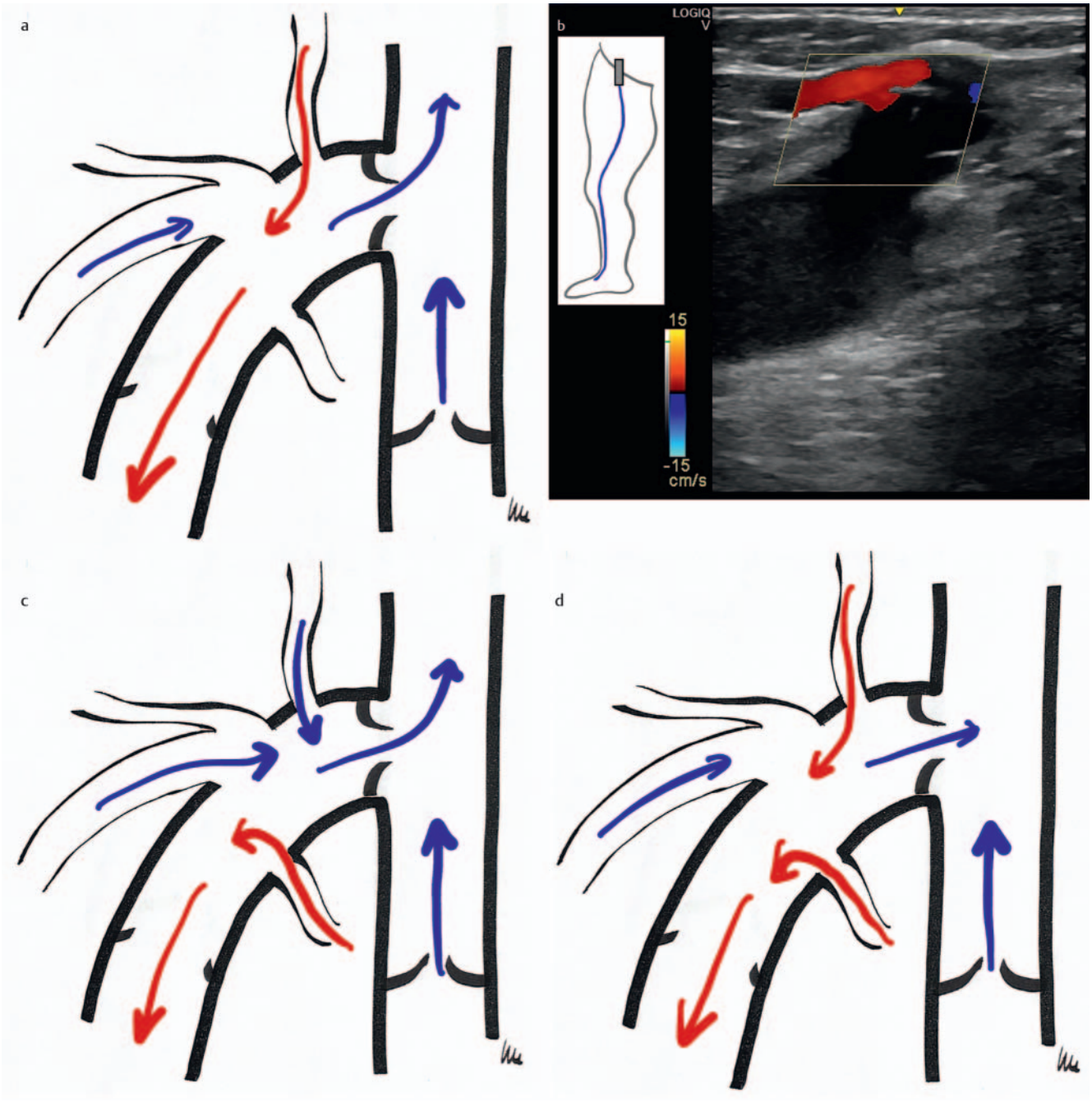
In 1.1 %, we find simultaneous reflux from the common femoral vein and the superior veins into the anterior accessory saphenous vein with competent preterminal valves (▶ **Fig. 13a**).

Type 4 reflux with both valves being competent but with reflux from an SFJ tributary into the anterior accessory saphenous vein was not defined in Stücker's original publication on staging [14], although it is present in 3.7 % of cases according to Zollmann (▶ **Fig. 13b**) [16].

The course of the small saphenous vein

The small saphenous vein (SSV) runs along the back of the calf from the lateral malleolus to the popliteal fossa, where it drains into the popliteal vein at various levels (▶ **Fig. 14**).

In the calf, it is clearly contained in the fascial compartment above the muscle fascia and below the saphenous fascia (▶ **Fig. 15**). Aplasia has not been described for the SSV, and segmental duplication in only 1 % of cases. Rarely, a small artery runs besides the SSV, and this must not be punctured during sclerotherapy. Duplex ultrasound scanning along the vein beforehand is therefore essential.



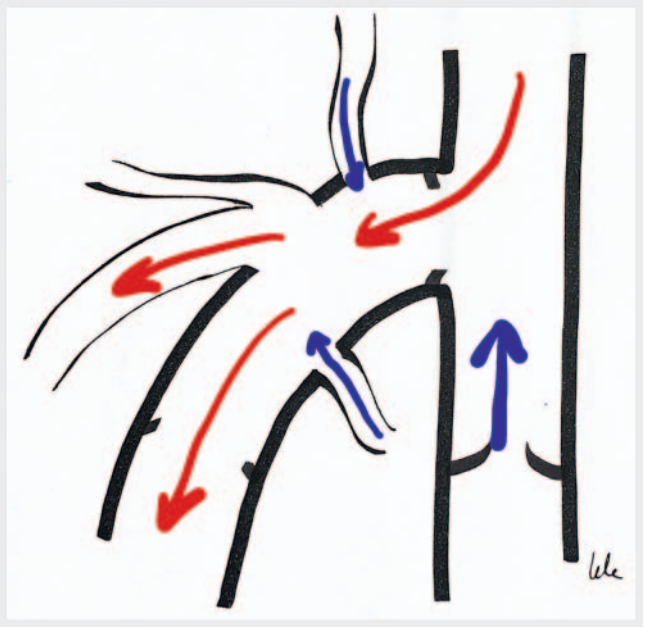
▶ **Fig. 9** Stücker Type 2. Competent terminal valve and incompetent preterminal valve. **a** Reflux from the epigastric vein into the great saphenous vein. Source: Arrien GmbH. **b** Longitudinal section through the groin showing the reflux (red) filling the great saphenous vein behind the competent terminal valve. Source: Arrien GmbH. **c** Reflux from the pudendal vein into the great saphenous vein. Source: Arrien GmbH. **d** Reflux from both the epigastric and pudendal veins into the great saphenous vein. Source: Arrien GmbH.

Saphenopopliteal junction

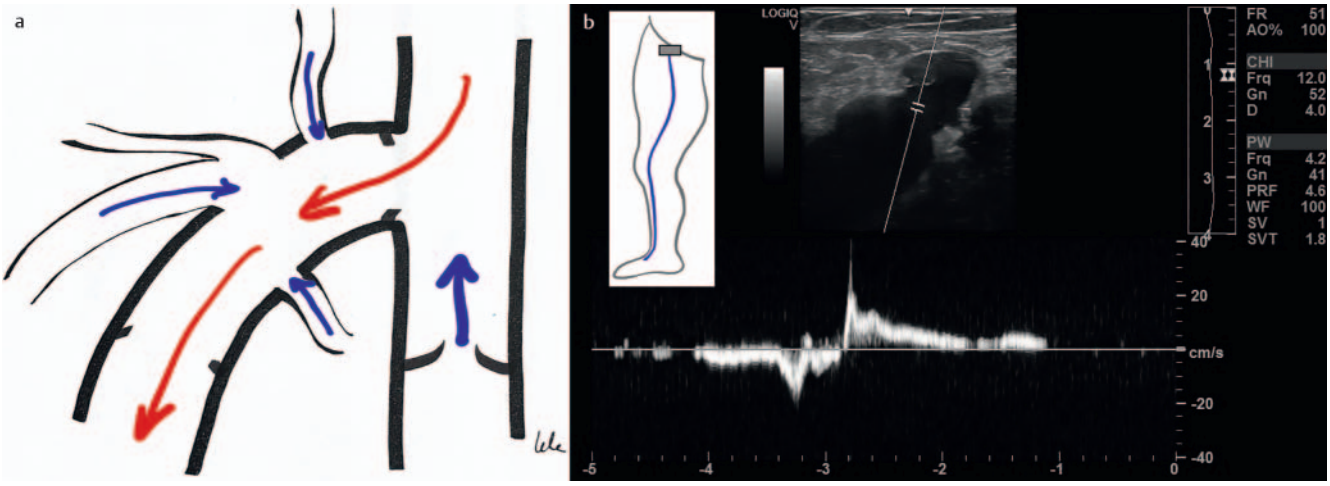
The junction of the SSV with the popliteal vein is usually at the level of the knee joint or up to 5 cm above it. It can, however, be much further proximal in the thigh or very rarely via a muscle vein distal to the popliteal fossa. In 60 % of cases there is a 'thigh extension of the small saphenous vein' which, depending on its course, is also referred to as the Giacomini vein (see article by Valesky and Brenner in this issue). The variants of the saphenopopliteal junction were summarised in the UIP anatomy consensus document as follows [17]:

- Type A: The SSV clearly joins the deep vein (with or without the presence of a Giacomini vein
  - A1: The SSV joins the popliteal vein independently of the muscle veins (▶ **Fig. 16a, b**)
  - A2: The SSV receives muscle veins as tributaries before it joins the popliteal vein (▶ **Fig. 16c, d**).
- Type B: The SSV continues upwards as the thigh extension (Giacomini vein) and there is only a very thin vessel anastomosing with the deep system, which may almost be considered a perforating vein (▶ **Fig. 17a**).
- Type C: There is no connection between the SSV and the deep veins. No reflux is then found in the SSV (▶ **Fig. 17b, c**).

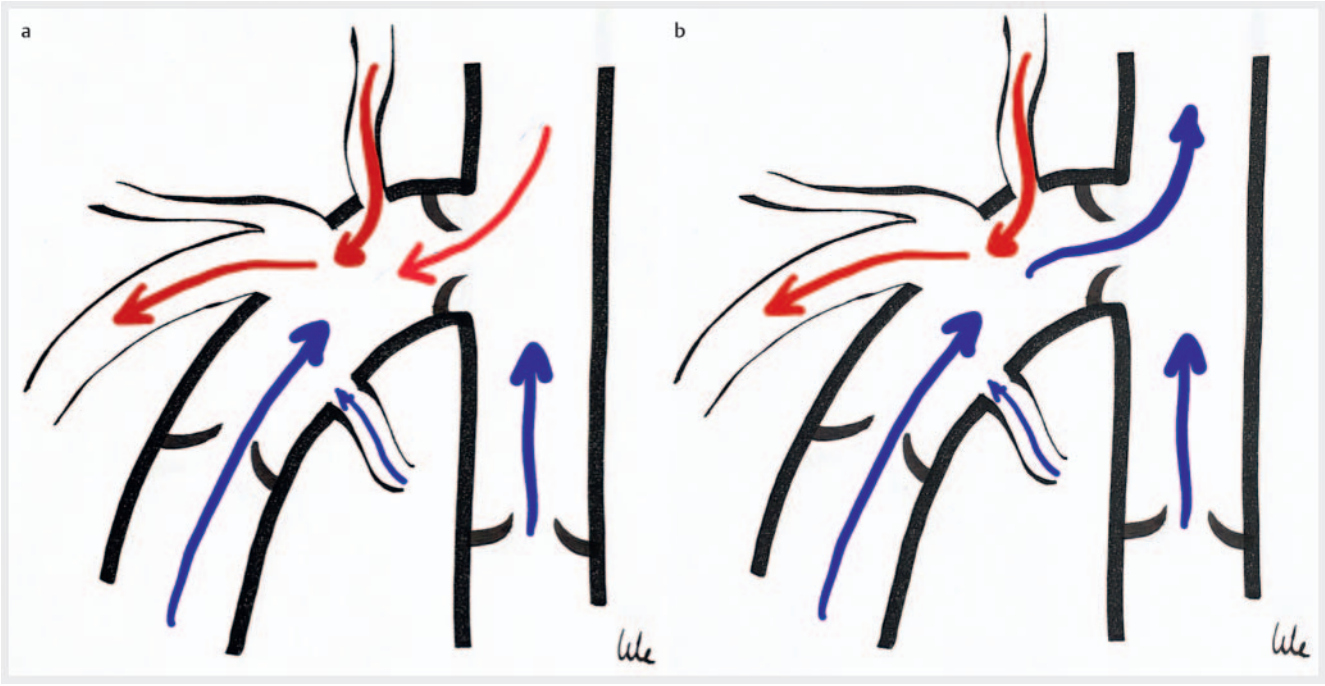
▶ **Fig. 10** Reflux from the epigastric vein into the great saphenous vein and the anterior accessory saphenous vein. Source: Arrien GmbH.



▶ **Fig. 12** Axial reflux into the great saphenous vein and also the anterior accessory saphenous vein. Source: Arrien GmbH.



▶ **Fig. 11** **a** Diagram showing the reflux with incompetence of both the terminal and preterminal valves. Source: Arrien GmbH. **b** Measurement of the reflux at the terminal valve in transverse section, the PW curve is recorded directly at the junction between the great saphenous vein and the deep vein. Source: Arrien GmbH.



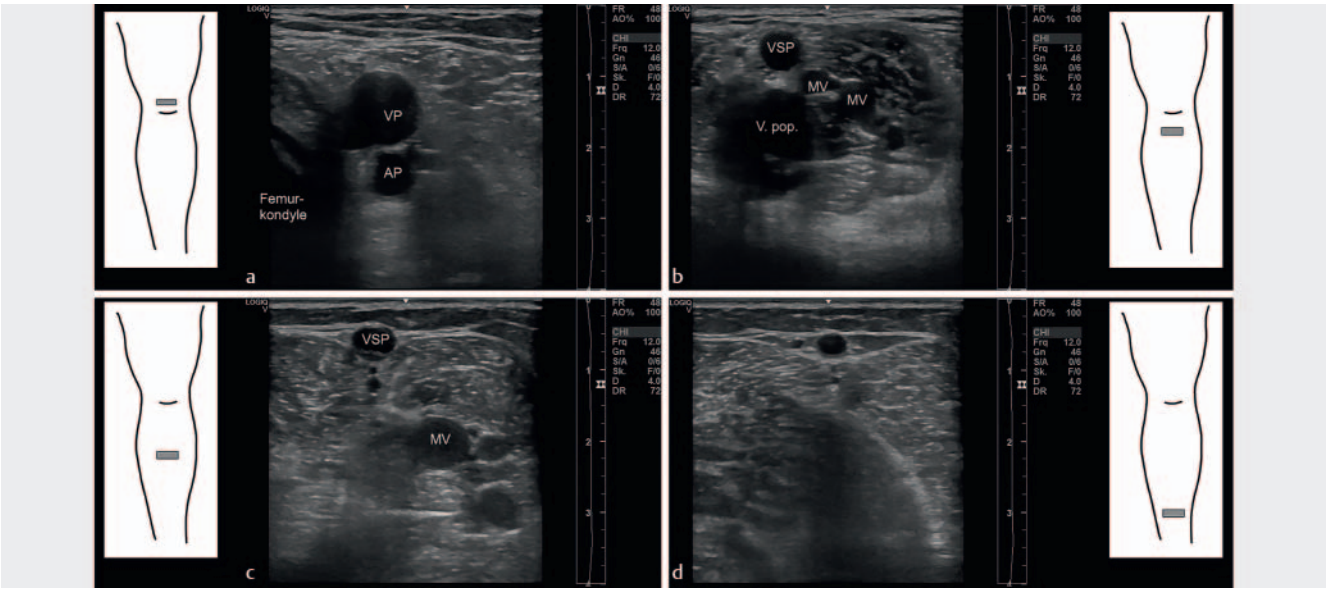
▶ **Fig. 13** **a** Diagram showing the reflux from the deep leg vein and an SFJ tributary into the anterior accessory saphenous vein. Source: Arrien GmbH. **b** Diagram showing the reflux from only one SFJ tributary into the anterior accessory saphenous vein (Stücker type 4). Source: Arrien GmbH.

▶ **Fig. 14** Course of the small saphenous vein (SSV) on the back of the leg from the lateral malleolus to the popliteal fossa. Left: junction at the level of the fossa. Right: opening into the deep venous system just above the popliteal fossa. Source: Arrien GmbH.

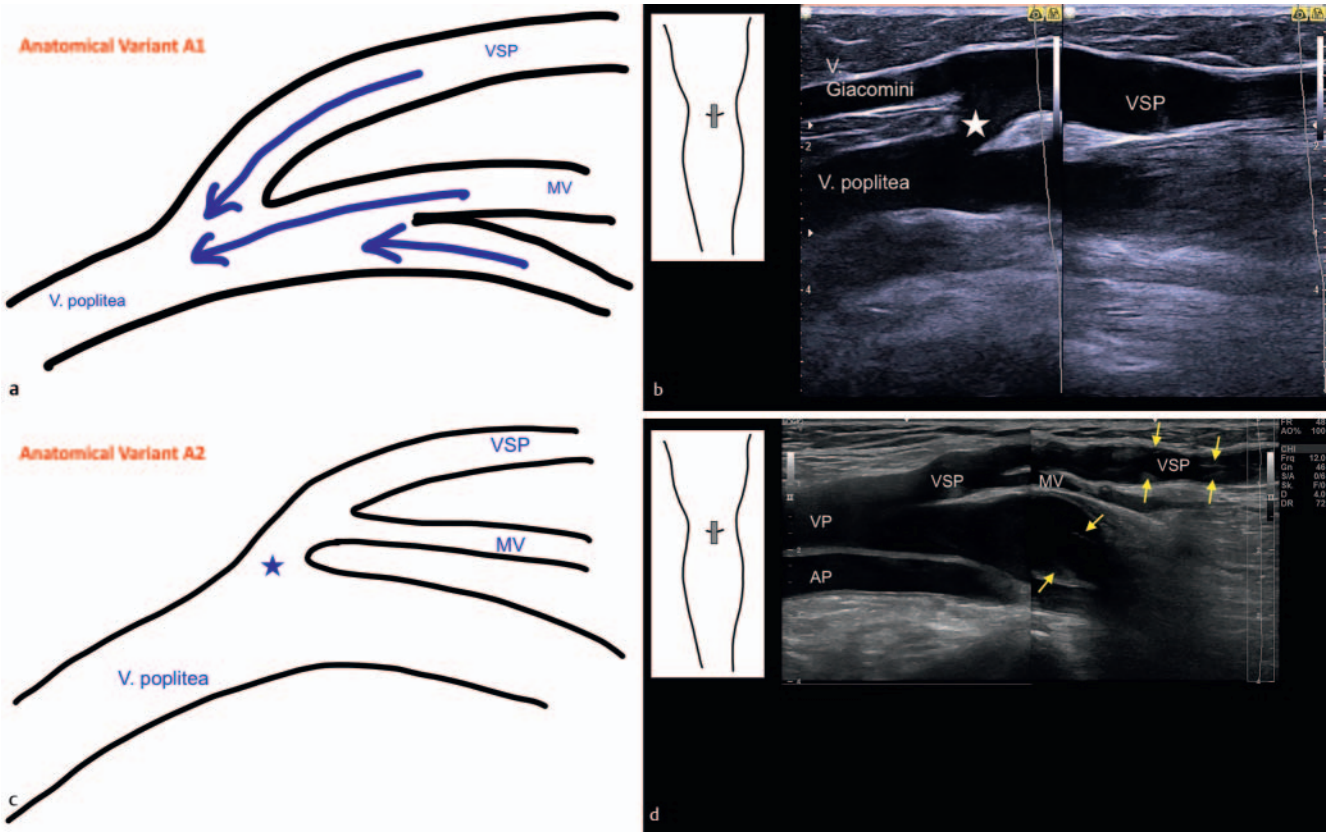
The very variable anatomy of the SSV drainage, especially the fact that it sometimes receives muscle veins as tributaries at the junction, makes a preoperative duplex ultrasound examination of the area absolutely essential. It is relevant for planning the type of procedure and the level of intervention: if the vein drains at a very high level, it usually cannot be reached surgically, at least not without a very large incision. In the case of tributary muscle veins, the SSV must be separated from them distally in order to prevent very painful muscle vein thrombosis.

Summary

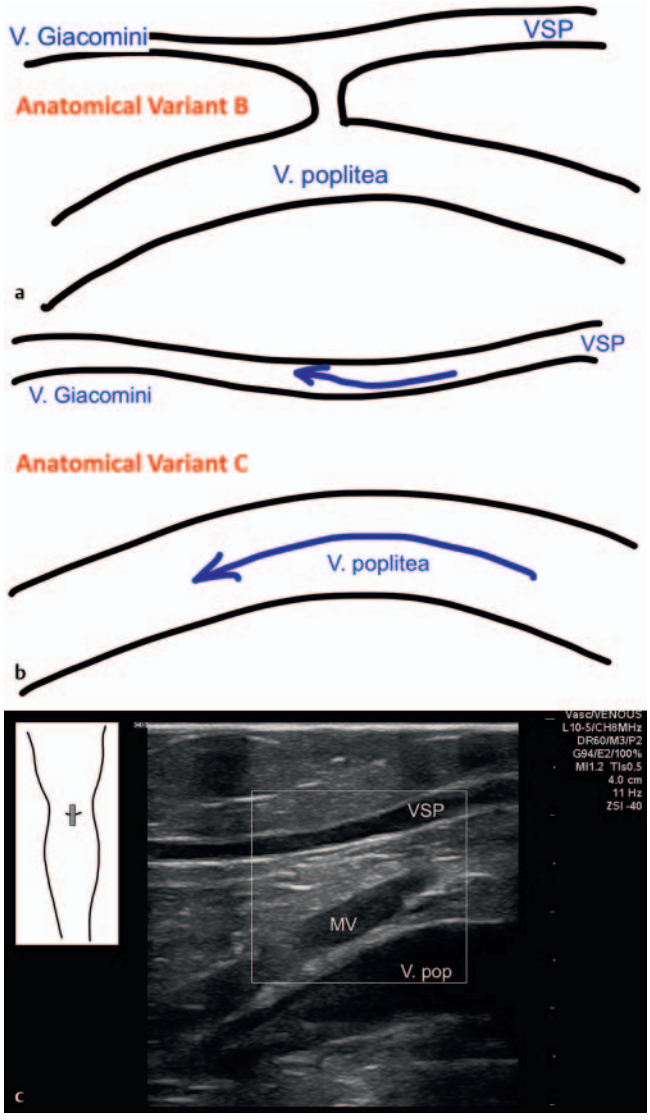
The great saphenous vein and less often the small saphenous vein are most frequently involved in the recirculation with varicose veins. Knowledge of their anatomy and the possible variations of normal is fundamental for diagnosis and planning treatment. As ultrasonography is the gold standard in the investigation of the leg veins today, an understanding of the venous anatomy as seen on ultrasound scans is always necessary.



▶ **Fig. 15** Transverse section through the small saphenous vein (SSV) from proximal to distal. **a** Transverse section just above the popliteal fossa. Only the popliteal vein (VP) and the popliteal artery (PA) can be seen; the SSV is not visible. Femur-condyle = femoral condyle. Source: Arrien GmbH. **b** Transverse section just distal to the opening in the SSV. Muscle veins are also visible in the immediate vicinity of the PV and the SSV. VSP = Small saphenous vein, V. pop = popliteal vein, MV = muscle vein. Source: Arrien GmbH. **c** Transverse section in the proximal third of the calf: the SSV runs in the fascial compartment; muscle veins can be seen in the underlying muscles. Source: Arrien GmbH. **d** More distal transverse section with very flattened fascial compartment of the SSV. Source: Arrien GmbH.



▶ **Fig. 16** Diagram showing the opening of the small saphenous vein (VSP) into the popliteal vein (V. poplitea) in relation to the muscle veins (MV). Asterisk: saphenopopliteal junction. **a** Type A1 junction – the SSV drains into the popliteal vein; the muscle veins open into the popliteal vein independently of the SSV. Source: Arrien GmbH. **b** Longitudinal section through the popliteal fossa, showing a type A1 junction in the presence of a Giacomini vein. Source: Arrien GmbH. **c** Diagram of type A2 junction. Source: Arrien GmbH. **d** Longitudinal section through the popliteal fossa showing a type A2 junction. The yellow arrows indicate valve leaflets (AP popliteal artery, VP = popliteal vein). Source: Arrien GmbH.



▶ **Fig. 17** **a** Type B junction with axis between the small saphenous vein (VSP) and the Giacomini vein, with a narrow connection to the popliteal vein, which appears more like a perforator. Source: Arrien GmbH. **b** Type C junction without any connection between the SSV and the popliteal vein. Source: Arrien GmbH. **c** Ultrasound scan of a type C junction. The small saphenous vein is usually competent with this type of junction. Source: Arrien GmbH.

Conflict of Interest

The authors declare that they have no conflict of interest.

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